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Money and the U.S. Economy in the 1980s: A Break From the Past? (p. 2)

Lawrence J. Christiano

Do Sterilized Interventions Affect Exchange Rates? (p.14)

Warren E. Weber

Federal Reserve Bank of Minneapolis

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Address questions to the Research Department, Federal Reserve Bank, Minneapolis, Minnesota 55480 (telephone 612-340-2341).

Do Sterilized Interventions Affect Exchange Rates?

Warren E. Weber
Research Officer
Research Department
Federal Reserve Bank of Minneapolis

On September 22, 1985, at New York's Plaza Hotel, the governments of the Group of Five countries (France, Japan, the United Kingdom, the United States, and West Germany) announced a coordinated program to depreciate the U.S. dollar against other major currencies. A major part of this program was a commitment by these countries to intervene against the dollar in foreign exchange markets. In the next six months or so, the value of the dollar fell about 20 percent (on a trade-weighted basis).

This coincidence of foreign exchange market interventions and a fall in the value of the dollar might seem to indicate that such interventions are a powerful tool with which policymakers can affect exchange rates and, therefore, potentially output and inflation. However, because foreign exchange market intervention involves the exchange of one currency for bonds denominated in another, it can affect an intervening country's monetary base (currency plus commercial bank reserves). As a result, any effects of an intervention on exchange rates may be due to changes in the monetary base—which suggests that the effects may be due to changes in monetary policy rather than intervention.

Nonetheless, a country can intervene in the foreign exchange market without changing its monetary base. Interventions conducted in this way are called *sterilized.*[1] But do sterilized interventions affect exchange rates? If the answer is yes, policymakers have a third policy tool (besides monetary and fiscal policy) with which to affect the economy. Economic theory suggests that a yes answer is possible. Unfortunately, though, the empirical evidence overwhelmingly says that in fact the answer is no.

Sterilizing Foreign Exchange Interventions

This section presents the mechanics of a sterilized foreign exchange market intervention. It shows that although a sterilized intervention leaves a country's monetary base unchanged, the intervention does change the quantities of domestic and foreign bonds in the portfolio of its central bank. Thus, the quantities of various bonds available for private agents to hold in their portfolios are also changed—which could affect exchange rates.

To understand the mechanics of a foreign exchange intervention by the United States, compare it to an open market operation conducted by the Federal Reserve. An open market operation involves the exchange of liabilities of the Fed (essentially, commercial bank reserves at the Fed) for U.S. government securities. For example, suppose the Fed sells $50 million of U.S. government securities from its portfolio. The effects of such a transaction are shown at the top of the accompanying table. The Fed's transfer of U.S. government

[1]Technically, an intervention is said to be sterilized only if the monetary base in all countries is unaffected by the intervention. However, the narrower definition is adequate here and will greatly simplify the discussion. For obvious reasons, an intervention in which the monetary base of one or more countries is affected is called *unsterilized.*

Accounting for a Foreign Exchange Intervention

Type of Transaction		Federal Reserve: Assets	Federal Reserve: Liabilities	U.S. Commercial Banks: Assets	U.S. Commercial Banks: Liabilities	German Commercial Banks: Assets	German Commercial Banks: Liabilities
U.S. Open Market Operation (Sale of U.S. Securities)	(1)	U.S. Secs. -$50 mil.		U.S. Secs. +$50 mil.			
	(2)		Reserves -$50 mil.	Reserves -$50 mil.			
U.S Foreign Exchange Intervention (Sale of German Marks)							
Unsterilized	(1)	German Secs. -$50 mil.				German Secs. +$50 mil.	
	(2)				Deposits of German Banks -$50 mil.	Deposits at U.S. Banks -$50 mil.	
	(3)		Reserves -$50 mil.	Reserves -$50 mil.			
Sterilized	(1)	German Secs. -$50 mil.				German Secs. +$50 mil.	
					Deposits of German Banks -$50 mil.	Deposits at U.S. Banks -$50 mil.	
			Reserves -$50 mil.	Reserves -$50 mil.			
	(2)	U.S. Secs. +$50 mil.		U.S. Secs. -$50 mil.			
			Reserves +$50 mil.	Reserves +$50 mil.			

securities to commercial banks is labeled transaction (1). The commercial banks pay for the securities with their reserves at the Fed; that is labeled transaction (2).[2] The overall effect of this open market sale of U.S. government securities is to decrease the reserves of the U.S. banking system—and, therefore, the U.S. monetary base—here, by $50 million.

A foreign exchange intervention also involves the exchange of liabilities of the Fed, but in this case they are exchanged for foreign government securities (de-

[2]Usually, this open market operation would be carried out by the Fed selling the U.S. government securities to a government securities dealer, which would pay for them using a check drawn on its demand deposits with a U.S. commercial bank. Assuming that the securities are sold directly to a commercial bank simply removes the need to carry along an extra account for the securities dealer.

nominated in the currency of the issuing country).[3] To continue the above example, suppose that instead of selling $50 million of U.S. government securities from its portfolio, the Fed sells the market equivalent of $50 million of the securities of another government—say, West Germany. This would be considered a foreign exchange intervention by the Fed in favor of the dollar and against the deutsche mark because the intention of such an intervention is to raise the value of the dollar relative to the mark by decreasing the supply of dollars relative to the supply of marks.

The mechanics of this foreign exchange intervention are shown in the middle of the table. The intervention begins with the Fed selling some of its holdings of German government securities to German commercial banks. This transfer of securities is transaction (1). The German banks pay for the securities out of their accounts with U.S. commercial banks, in transaction (2). On receipt of the payment from the German banks, the Fed debits the reserves of U.S. commercial banks, transaction (3).[4]

This foreign exchange intervention has the same overall effect on U.S. bank reserves as does the open market sale of U.S. government securities. Both actions remove $50 million of U.S. commercial bank reserves. The difference between the two actions is that the open market operation decreases the Fed's holdings of domestic assets whereas the foreign exchange intervention decreases its holdings of foreign assets (more precisely, assets denominated in foreign currency units).[5]

The intervention illustrated in the middle of the table is unsterilized because the U.S. monetary base has been affected. Any such effect can be neutralized—the intervention sterilized—however, by an offsetting open market operation. For example, the Fed's sale of the market equivalent of $50 million of German government securities can be sterilized by a Fed open market purchase of $50 million of U.S. government securities. The bottom of the table shows those transactions. Transaction (1) is the unsterilized foreign exchange intervention; transaction (2) is the open market purchase of U.S. government securities. Clearly, the overall effect of these transactions is a sterilized intervention because they leave the U.S. monetary base unchanged.

Note, however, that something is changed by a sterilized intervention. Though the level of the U.S. monetary base is the same after such an intervention, the composition of the Fed's portfolio of domestic and foreign assets is different.

Since a sterilized intervention does not affect the total available stock of assets, this means that the composition of private agents' portfolios of domestic and foreign assets is also changed. And since, for markets to clear, private agents must adjust their demands for assets to equal the supplies available to them, rates of return and exchange rates might reasonably be expected to adjust as well.

Exchange Rate Effects: A Theoretical Possibility . . .

A simple theoretical model can investigate whether or not exchange rates are affected by a change in the quantities of bonds denominated in domestic and foreign currencies that are available to the private sector. As is appropriate, this model emphasizes private agents' demands for assets denominated in different currencies.[6] In general, the model's results are ambiguous: sterilized interventions may or may not have exchange rate effects, depending on the values of certain parameters. Under certain conditions, however, the model says sterilized interventions do not affect exchange rates.

The model has only two countries—a home country and a foreign country—and four assets—the currencies of the two countries and bonds denominated in each of the two currencies. In such an economy, the liabilities of a central bank must equal its holdings of bonds denominated in either currency, as was illustrated in the last section. Neither country has commercial banks, so each country's money supply equals the liabilities of its central bank.

In more technical terms, then, the home country money supply at time t, $M(t)$, must equal the value of the home central bank's holdings of bonds denominated

[3] For other presentations of the money supply effects of foreign exchange interventions, see Balbach 1978 and Kubarych 1977–78.

[4] The mechanics of a foreign exchange intervention are not unique; the German bonds could be sold to agents other than German commercial banks. Thus, the transactions in the table merely illustrate one way the intervention could occur. Nonetheless, no matter how it is accomplished, the final effects on private and central bank portfolios are those shown in the table.

[5] Neither the open market operation nor the U.S. foreign exchange intervention affects German commercial bank reserves or the German monetary base. Of course, other countries' central banks can intervene in the foreign exchange market, too. An intervention by West Germany's central bank, the Bundesbank, for example, is the mirror image of this illustration of an intervention by the Federal Reserve. That is, intervention in favor of the dollar by the Bundesbank increases the reserves of the German banking system and the German monetary base without changing U.S. bank reserves or the U.S. monetary base. The reserves of the German central bank could also have been affected if the Fed had used its swap line of credit with the Bundesbank. This type of intervention is described in the Appendix.

[6] Because this model of exchange rate determination concentrates on the supplies of and demands for assets, it is very similar to the portfolio balance model of exchange rate determination. For an excellent review of that model, see Branson and Henderson 1985.

in units of the home currency, $B_g(t)$, plus the value of its holdings of bonds denominated in the foreign currency, $F_g(t)$, in terms of its own currency. That is,

$$(1) \qquad M(t) = B_g(t) + e(t)F_g(t)$$

where $e(t)$ is the exchange rate at time t in units of home currency per unit of foreign currency.[7] Similarly, the foreign country money supply, $M^*(t)$, must equal the value of the foreign central bank's holdings of bonds denominated in the foreign currency, $F_g^*(t)$, plus the value of its holdings of bonds denominated in the home currency, $B_g^*(t)$ in foreign currency units. That is,

$$(2) \qquad M^*(t) = [B_g^*(t)/e(t)] + F_g^*(t).$$

Throughout the analysis, the levels of the money supplies, $M(t)$ and $M^*(t)$, are assumed to be determined exogenously (outside the model), as are the central banks' holdings of bonds denominated in the foreign currency, $F_g(t)$ and $F_g^*(t)$. Once the levels of these variables have been set, central banks' holdings of bonds denominated in the home currency, $B_g(t)$ and $B_g^*(t)$, are determined by (1) and (2), respectively.

The sterilized intervention example of the previous section provides a good illustration of this point. Call the United States the home country and West Germany the foreign country. When the Fed intervenes in the foreign exchange market by selling German government bonds, it decreases its holdings of $F_g(t)$. When the Fed sterilizes this intervention by buying U.S. government bonds, it increases its holdings of $B_g(t)$. And since the U.S. money supply must be left unchanged, the Fed's increase in its holdings of U.S. government bonds must be exactly offset by the decrease in its holdings of German bonds; that is, these changes must satisfy $dB_g(t) = -d[e(t)F_g(t)]$. A sterilized intervention by the foreign country must satisfy a similar restriction.

The asset demand functions of private agents in this economy are formulated under two assumptions: private agents can only hold the currency of the country in which they reside, and private agents' asset demands depend only on expected rates of return and aggregate wealth. For now, no restrictions are placed on how interchangeable agents consider bonds denominated in different currencies since there are several reasons agents might consider such bonds less than perfect substitutes. One is the existence of market frictions, such as the risk that currency controls might be imposed. And if agents are risk averse, another is differences in the return distributions of bonds due to uncertain exchange rate changes or differences in default risks, for example.

Specifically, the asset demands of home country residents are assumed to depend on their aggregate wealth, $W(t)$, and the rates of return on the two types of bonds, expressed in terms of the home currency. The rate of return on bonds denominated in the home currency is $r(t)$, and that on bonds denominated in the foreign currency is $r^*(t) + \pi(t)$, where $r^*(t)$ is the rate of return in terms of the foreign currency on bonds denominated in the foreign currency and $\pi(t)$ the expected rate of depreciation of the home currency relative to the foreign currency.[8] Therefore, home residents' demand for bonds denominated in the home currency is

$$(3) \qquad B_p(t) = b_p[r(t), r^*(t) + \pi(t), W(t)].$$

It is assumed to depend positively on $r(t)$ and $W(t)$ and negatively on $r^*(t) + \pi(t)$. Home demand for foreign bonds is

$$(4) \qquad e(t)F_p(t) = f_p[r(t), r^*(t) + \pi(t), W(t)].$$

It is assumed to depend positively on $r^*(t) + \pi(t)$ and $W(t)$ and negatively on $r(t)$.

Once these two demand functions have been specified, home country residents' demand for money can be determined from their budget constraint

$$(5) \qquad M(t) + B_p(t) + e(t)F_p(t) = W(t)$$

which states that their holdings of money and bonds must equal their wealth.

Similar assumptions are made about the asset demands of foreign country residents. Specifically, the asset demands of foreign residents are assumed to depend on their aggregate wealth, $W^*(t)$, and the rates of return on the two types of bonds, expressed in terms of the foreign currency. The rate of return in terms of the foreign currency on bonds denominated in the home currency is $r(t) - \pi(t)$, and that on bonds denominated in the foreign currency is $r^*(t)$. Therefore, foreign residents' demand for bonds denominated in the home currency is

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[7]Because the exchange rate is defined as units of domestic currency per unit of foreign currency, an increase in $e(t)$ indicates that the domestic currency has depreciated.

[8]The expected rate of depreciation of home currency, $\pi(t)$, is defined as $\{E[e(t+1)]/e(t)\} - 1$, where E is the expectations operator conditioned on all information available at time t.

(6) $B_p^*(t)/e(t) = b_p^*[r(t) - \pi(t), r^*(t), W^*(t)]$.

It is assumed to depend positively on $r(t) - \pi(t)$ and $W^*(t)$ and negatively on $r^*(t)$. Foreign demand for bonds denominated in the foreign currency is

(7) $F_p^*(t) = f_p^*[r(t) - \pi(t), r^*(t), W^*(t)]$.

It is assumed to depend positively on $r^*(t)$ and $W^*(t)$ and negatively on $r(t) - \pi(t)$. Given these bond demands, foreign country residents' demand for money can be determined from their budget constraint, which is analogous to (5).

Markets are cleared when supply equals demand. The total stock of bonds denominated in the home currency, $\bar{B}(t)$, and the total stock of bonds denominated in the foreign currency, $\bar{F}(t)$, are determined by the past government deficit policies in the respective countries. These policies are assumed to have been set exogenously, so that the total stocks of both types of bonds are given.

Consequently, the market for bonds denominated in the home currency is cleared when

(8) $\bar{B}(t) = B_p(t) + B_p^*(t) + B_g(t) + B_g^*(t)$.

Similarly, the market for bonds denominated in the foreign currency is cleared when

(9) $\bar{F}(t) = F_p(t) + F_p^*(t) + F_g(t) + F_g^*(t)$.

The market for home currency is cleared when the supply of home currency, as given by (1), equals the demand for it, from (5). And when the markets for the two bonds and the home currency are cleared, so will be the market for foreign currency, according to Walras' law.

Since the asset demands given by (3), (4), (6), and (7) are specified only in terms of implicit functions, the model cannot be solved explicitly for equilibrium return or exchange rates. However, a very useful linear approximation of the solution for the expected rate of depreciation of the home currency is[9]

(10) $$\pi(t) = \alpha_0 + \alpha_1 \bar{B}(t) + \alpha_2 e(t)\bar{F}(t) + \alpha_3 M(t) - \alpha_1 e(t) M^*(t) + (\alpha_1 - \alpha_2) e(t)[F_g(t) + F_g^*(t)] + \alpha_4 W(t) + \alpha_5 e(t) W^*(t).$$

The parameters α_1 through α_5 are complicated functions of the derivatives of the bond demand functions of both home and foreign residents, and unfortunately, the assumptions about the signs of those derivatives do not provide enough information to sign any of the α's. According to (10), the rate of depreciation of the home currency depends in an indeterminate way on the total stock of both types of bonds, home and foreign money supplies, home and foreign wealth, and central banks' holdings of bonds denominated in foreign currency.[10]

Fortunately, the inability to sign the α's does not limit (10)'s usefulness for determining whether or not sterilized interventions can affect exchange rates. Consider the discussion of sterilized interventions in the last section. When the Fed (the home country) intervenes in favor of the dollar by selling German (foreign country) securities and then sterilizes by buying U.S. securities, $e(t)F_g(t)$ decreases with $M(t)$ unchanged. Thus, if $\alpha_1 > \alpha_2$, the sterilized intervention makes the dollar depreciate more rapidly relative to the mark. If $\alpha_1 = \alpha_2$, though, the sterilization leaves exchange rates unchanged.

A natural question, then, is whether theory restricts the value of $\alpha_1 - \alpha_2$. The answer is no; without further restrictions on the derivatives of the bond demand functions, the value of $\alpha_1 - \alpha_2$ is unrestricted, and sterilized interventions may or may not affect exchange rates.

A restriction can be placed on bond demands, however, that will make sterilized interventions not affect exchange rates. The restriction is that residents of both countries consider bonds denominated in different currencies *perfect substitutes;* more precisely, while residents of both countries have demand functions for total bond holdings, they are indifferent to the composition of their bond portfolios as long as both types of bonds have the same expected rates of return. Solving the model given by (1)–(9) under this perfect substi-

[9]Equation (10) is a linear approximation of the solution to the model only under the assumption that $e(t)$ is constant when any of the exogenous variables in the model change. This is not the strictly correct solution to the model which would be obtained by solving for $e(t)$ under the assumption that $E[e(t+1)]$ is formed rationally. Such a solution is not possible, however, due to the model's implicit functions. Therefore, I opt to solve the model for $\pi(t)$ holding $e(t)$ constant in order to let expected exchange rate changes affect relative rates of return. That is important because the model is one of portfolio choice. Note that solving the model for $e(t)$ holding $\pi(t)$ constant gives a solution similar to (10) except that $\pi(t)$ is on the right side of the equation and all $e(t)$'s are eliminated. More important, the result that the coefficients on the central bank holdings of bonds denominated in the foreign currency have to be nonzero for sterilized interventions to affect exchange rates still holds.

[10]Although the assumptions don't sign the α's, they do imply that α_1, α_2, and α_3 all have the same sign.

tutes restriction yields the result that $\alpha_1 = \alpha_2$. Thus, under this restriction, changes in the composition of central bank portfolios, such as those due to a sterilized intervention, leave the rate of depreciation of the exchange rate unchanged. This makes good economic sense because when private agents consider bonds denominated in different currencies perfect substitutes, they do not require any changes in the relative rates of return on those bonds to offset the change in the composition of available bonds which results from the sterilized intervention.

. . . Rejected by the Evidence

Since theory leaves open the question of whether sterilized interventions affect exchange rates, empirical evidence must be consulted. Two basic types of empirical evidence are available. One is evidence on whether bonds denominated in different currencies are perfect substitutes. If they are, then $\alpha_1 = \alpha_2$ and sterilized interventions cannot affect exchange rates. Unfortunately, although most empirical studies show bonds to be perfect substitutes, this evidence is not conclusive. The other type of evidence is direct evidence on the relative magnitude of α_1 and α_2 from empirical studies of the effects of bond holdings on exchange rates, obtained either by estimating equations similar to (10) or by estimating the bond demand equations of the model. These studies provide almost no evidence that sterilized interventions affect exchange rates. And taken together, all the empirical studies make a strong case that sterilized interventions do not affect exchange rates.

Bond Substitutability

When bonds denominated in different currencies are perfect substitutes, their expected rates of return must be equal, so that

$$(11) \quad r(t) - r^*(t) - \pi(t) = 0.$$

If their rates of return were not equal, the demand for the bond with the higher rate would be infinite and markets could not be cleared.

When bonds denominated in different currencies are not perfect substitutes, however, (11) does not have to hold and some or all of the variables on the right side of (10) could help explain $r(t) - r^*(t) - \pi(t)$. Thus, the empirical test of whether bonds denominated in different currencies are perfect substitutes is the test of whether any of the exogenous variables of the model have nonzero coefficients in a regression equation with the term $r(t) - r^*(t) - \pi(t)$ as the dependent variable.[11]

Since the empirical studies of bond substitutability have this term as their dependent variable, they encounter the problem of how to measure the expected future exchange rate to obtain a value for $\pi(t)$. They solve the problem by assuming that expectations are rational, so that $E[e(t+1)]$ equals actual $e(t+1)$ plus a white noise error term (an unpredictable element).[12] The studies differ in the currency denomination of the bonds they consider, the period and sampling frequency of their data, and the specification of the right side of their estimating equation.

Frankel (1982a) uses monthly data from January 1974 to October 1978 to examine the substitutability of bonds denominated in West German marks and U.S. dollars. The right side of his regression equation has a constant term and the ratio of mark-denominated bonds to wealth. He finds that neither variable has a regression coefficient significantly different from zero. Though he does not test whether both coefficients are simultaneously equal to zero, he interprets his regression results as indicating that German and U.S. bonds are perfect substitutes. Frankel comes to the same conclusion in a later study (1982b) which uses monthly data for a longer period from (June 1973 to August 1980) to examine bonds denominated in more currencies (six). This study uses a system of regression equations specified so that he can test the null hypothesis that all regression coefficients are simultaneously equal to zero. He is unable to reject that hypothesis, again indicating perfect substitutability of bonds.

Dooley and Isard (1983) obtain very similar results using end of quarter data from 1973 to 1978. They too study the substitutability of bonds denominated in West German marks and U.S. dollars. On the right side of their estimating equation, they include only a constant term and dollar-denominated bonds. Like Frankel (1982a), they find no statistically significant coefficients in their regression equations. However, they do not test the hypothesis that both regression coefficients equal zero.

Rogoff (1984) obtains the same type of results for

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[11]Since $r(t) - r^*(t) - \pi(t)$ is the uncovered interest differential between home and foreign bonds, *uncovered interest rate parity* is said to exist when (11) holds. Since the uncovered interest differential is assumed to be nonzero when bonds denominated in different currencies are imperfect substitutes, $r(t) - r^*(t) - \pi(t)$ is also referred to as the *exchange rate risk premium*.

[12]Because these studies have this exchange rate expectations assumption, they are actually testing the joint hypothesis that bonds denominated in different currencies are perfect substitutes and exchange rate expectations are rational. Nonetheless, I will consider evidence of nonzero coefficients in regression equations as evidence against perfect substitutability alone.

the substitutability of bonds denominated in U.S. and Canadian dollars using weekly data from March 1973 to December 1980. The right side of his regression equation includes only a constant and the ratio of home to foreign bonds. Although he also does not test the joint hypothesis of both regression coefficients equaling zero, he finds significant coefficients only for the subperiod from March 1973 to November 1976, and even then the coefficient on the bond ratio has what he considers an incorrect sign. Thus, overall his evidence argues against imperfect substitutability.

One study which does obtain some evidence of less than perfect substitutability is that by Danker et al. (1985). Using monthly data from February 1975 to December 1981, they study the substitutability of bonds denominated in West German marks, Japanese yen, and Canadian dollars with those in U.S. dollars. To study mark- and yen-denominated bonds versus U.S. dollar–denominated bonds, they use two estimating equations. One includes only home country (U.S.) variables (interest rates, income, wealth, and bonds); the other, only foreign country variables (wealth and bonds). To study the substitutability of Canadian versus U.S. dollar–denominated bonds, they combine the home and foreign country variables (interest rates, income, wealth, and bonds) in a single equation. For the mark/U.S. dollar equation with only home variables and for the Canadian/U.S. dollar equation, the hypothesis of perfect substitutability is rejected. But for the mark/U.S. dollar equation with only foreign variables and for both yen/U.S. dollar equations, that hypothesis is not rejected.

Stronger evidence against perfect substitutability is obtained by Loopesko (1983). She studies the substitutability of Eurodollar deposits denominated in West German marks, Japanese yen, French francs, British pounds, and Canadian dollars with such deposits denominated in U.S. dollars. She uses daily data starting between 1975 and 1979, depending on the currency denomination, and ending November 6, 1981. Her regression equation includes a constant term, lagged U.S. and German exchange market interventions, lagged exchange rates, and lagged differences between interest rates on the Eurodollars [versions of the term $r(t) - r^*(t) - \pi(t)$ in (11)]. In almost all cases, she is able to reject the null hypothesis of perfect substitutability.

The Danker et al. and Loopesko studies cover more currencies and longer time periods than most of the others, and the Danker et al. study pays the most attention to data construction. Nonetheless, the findings in these two studies do not seem strong enough to completely overturn the others'. For Danker et al., a major reason is that the U.S. interest rate is on both sides of some regression equations. Thus, even if that rate is replaced by an instrument when it appears as a right side variable, its coefficient would not be expected to be zero. This could bias the hypothesis tests in favor of rejecting perfect substitutability. And note that Danker et al. reject perfect substitutability only in those regression equations that have an interest rate as a right side variable. The same problem occurs in Loopesko's study with respect to exchange rates dated period $t-2$ ($t-1$ for Canada). If terms involving these exchange rates were omitted from the right side of her regression equations, some evidence in her paper suggests that the results would be less unfavorable to the perfect substitutability hypothesis.

In summary, the empirical studies of bond substitutability provide some evidence that bonds denominated in different currencies are perfect substitutes, so that $\alpha_1 = \alpha_2$, but this evidence is far from conclusive.[13]

Bond Effects

Stronger evidence that $\alpha_1 = \alpha_2$ comes from several empirical studies which include bonds in equations attempting to explain the determination of exchange rates.

Branson, Halttunen, and Masson (1977) estimate a modification of (10) in level form using monthly data from August 1971 to December 1976. They examine the West German mark/U.S. dollar exchange rate in a regression equation which includes both countries' money supplies and private holdings of foreign bonds. Since these asset (bond) variables do not directly correspond to those in (10), their regression coefficients must be interpreted in terms of (10). Since Branson, Halttunen, and Masson consider the total stocks of assets (bonds) to be fixed in the short run, I interpret an increase in private holdings of foreign assets as corresponding to a decrease in central bank holdings of foreign assets. Under this interpretation, the regression coefficient on private U.S. holdings of foreign assets in their analysis corresponds to $\alpha_2 - \alpha_1$ in (10), and their regression coefficient on private German holdings of foreign assets corresponds to $\alpha_1 - \alpha_2$. In their regres-

[13] Remember that tests of bond substitutability can only show that sterilized interventions do not have exchange rate effects if they find that bonds denominated in different currencies are perfect substitutes. Finding that such bonds are not perfect substitutes does not indicate that sterilized interventions have exchange rate effects because it does not show that $\alpha_1 \neq \alpha_2$. In other words, lack of perfect substitutability of bonds denominated in different currencies is a necessary but not sufficient condition for sterilized interventions to affect exchange rates.

sions, these coefficients have approximately equal but opposite signs as predicted, and neither is significantly different from zero, indicating that $\alpha_1 = \alpha_2$.[14]

Backus (1984) also estimates an equation similar to (10), but for the U.S. dollar/Canadian dollar exchange rate with quarterly data from 1971 to 1980. He estimates several regression equations, including as right side variables the Canadian money supply, private Canadian holdings of foreign assets, the total supply of assets denominated in Canadian dollars, a U.S. interest rate, and U.S. and Canadian income levels. He obtains negative but statistically insignificant coefficients on the regression coefficient of Canadian holdings of foreign assets which (under the above interpretation of such a variable) suggests that $\alpha_1 = \alpha_2$.

Similar results are obtained by Obstfeld (1983) using a different approach. He constructs a two-asset version of the model in the last section and estimates its demand equations. Specifically, he considers West Germany the home country and the United States the foreign country, and using monthly data from January 1975 to October 1981, he estimates the demand for home country money, the supply of home country money, and home and foreign demand for mark-denominated assets. He then uses these estimated demand functions to simulate the effect of a foreign exchange intervention equivalent to 10 percent of the German monetary base. When the intervention is sterilized, his simulations indicate that the mark would appreciate a mere 0.04 percent.

Altogether, the empirical evidence from the bond effect studies indicates that sterilized interventions do not affect exchange rates. More evidence which supports this conclusion, but is generated in a very different way, comes from two recent studies by Meese and Rogoff (1983a,b). They compare the out-of-sample forecasting performance of several different models of exchange rate determination, one of which is quite similar to (10). They use monthly data from March 1973 to June 1981 for the exchange rates between the U.S. dollar and the West German mark, the Japanese yen, and the British pound as well as for the trade-weighted value of the U.S. dollar. They find that, in general, the best predictor of the log of future exchange rates is the random walk model $\log[e(t)] = \log[e(t-1)] + \epsilon(t)$, where $\epsilon(t)$ is a white noise error term.[15] Since bond holdings do not appear in that model, sterilized interventions cannot affect exchange rates.

Conclusion

Do sterilized interventions affect exchange rates? Even though theory indicates that the answer may be yes, the empirical evidence shows that the answer is actually no, at least over time intervals of a month or more.

This answer implies that policymakers only have monetary and fiscal policy as tools with which to affect the economy. Thus, if they want to influence the exchange rate, they must use one of those two tools; sterilized interventions will have no effect. But, then, why should central banks intervene in foreign exchange markets at all? If only the size, not the currency composition, of central bank portfolios matters, then it is monetary policy which affects the economy, and any effect achievable by buying or selling foreign bonds is also achievable by buying or selling domestic bonds.

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[14]A later study by Branson, Halttunen, and Masson (1979) uses data through March 1978. In it the coefficient on private German holdings of foreign assets remains insignificant, but the coefficient on private U.S. holdings of foreign assets is negative and significantly different from zero. These differences make interpreting this evidence about the relative magnitudes of α_1 and α_2 difficult since the studies don't provide enough information to test whether the coefficients on the asset variables are equal to each other or simultaneously equal to zero.

A drawback of both Branson, Halttunen, and Masson studies (which is explicitly recognized by the authors) is that bond holdings are not measured directly. Instead, the bond series are cumulations of current account balances on some benchmark level of bond holdings. Such a procedure obviously omits any capital gains effects.

[15]See Meese and Rogoff 1983a, p. 10, for a description of how the forecasts are generated.

Appendix
Another Type of Foreign Exchange Intervention: The Swap

The Federal Reserve does not have to intervene in the foreign exchange market by selling foreign government bonds from its portfolio. Instead, the Fed can intervene by drawing on its *swap line*, or reciprocal short-term credit agreement, with another country's central bank and using the proceeds to buy that country's commercial bank deposits held in U.S. banks. Such an intervention by the Fed can affect the monetary base in both countries.

As an example, consider how such an intervention works between the United States and West Germany. (Today the Fed has swap agreements with 14 central banks and the Bank for International Settlements.) The Fed's swap agreement with the German central bank, the Bundesbank, lets it borrow marks in return for equivalent dollar deposits at the Fed. A swap of $50 million is shown as transaction (1) in the accompanying table.

Accounting for a Swap Intervention

	Federal Reserve		U.S. Commercial Banks		Bundesbank		German Commercial Banks	
Transaction	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
(1)	Deposits at Bundesbank +$50 mil.	Deposits of Bundesbank +$50 mil.			Deposits at Fed +$50 mil.	Deposits of Fed +$50 mil.		
(2)				Deposits of German Banks -$50 mil.			Deposits at U.S Banks -$50 mil.	
(3)	Deposits at Bundesbank -$50 mil.					Deposits of Fed -$50 mil.		
						Reserves +$50 mil.	Reserves +$50 mil.	
(4)		Reserves -$50 mil.	Reserves -$50 mil.					
(5)			U.S. Secs. -$50 mil.		U.S. Secs. +$50 mil.			
		Deposits of Bundesbank -$50 mil.			Deposits at Fed -$50 mil.			
		Reserves +$50 mil.	Reserves +$50 mil.					
(6)					German Secs. -$50 mil.		German Secs. +$50 mil.	
						Reserves -$50 mil.	Reserves -$50 mil.	

The Fed can use the newly created deposits at the Bundesbank to intervene in favor of the dollar. It does so by purchasing deposits of German commercial banks at U.S. banks, transaction (2) in the table. German commercial banks gain reserves when they sell the deposits because the Fed's payment is drawn on the Bundesbank, as in transaction (3). U.S. commercial banks lose reserves as a result because when the Fed acquires the German bank deposits, it is in effect receiving a check drawn on them. This reserve loss is shown as transaction (4). So far, then, the reserves of the German banking system have increased \$50 million and the reserves of the U.S. banking system have decreased \$50 million.

If this intervention is to be sterilized, the reserves of the German banking system must be decreased by the mark equivalent of \$50 million and the reserves of the U.S. banking system increased by \$50 million. Obviously, one simple way for this to occur is for the Fed and the Bundesbank to undertake the necessary open market operations—the Fed buying \$50 million of U.S. government securities and the Bundesbank selling the mark equivalent of \$50 million of German government securities. The net effects of these actions are the same as those of the sterilized intervention discussed in the text. Neither country's monetary base changes, the quantity of U.S. government bonds available for private portfolios decreases \$50 million, and the quantity of German government bonds available for private portfolios increases the mark equivalent of \$50 million.

If the intervention were sterilized by both central banks undertaking open market operations, however, it would leave the Bundesbank with a non–interest-bearing deposit at the Fed. Very likely, the Bundesbank will not leave its balance at the Fed in that form. Instead, it will use this deposit to buy interest-bearing U.S. government securities from U.S. commercial banks.* In the table, this is shown as transaction (5). Since the Bundesbank pays for the U.S. government securities with deposits at the Fed, the result is an increase in the reserves of the U.S. banking system. Thus, this action by the Bundesbank sterilizes the effects of the intervention on the U.S. monetary base. The Bundesbank can then sterilize the effects of the intervention on the German monetary base by an open market purchase of German government securities, transaction (6). The final result is the same as if each central bank had undertaken its own open market operation.

*Kubarych (1977–78) correctly points out that the Bundesbank does not buy U.S. government securities from U.S. commercial banks with its deposits at the Fed. Instead, it buys a nonmarketable security from the U.S. Treasury. He concludes that reserves will be added to the U.S. commercial banking system only if the Treasury spends the proceeds of this sale. However, if this is a new U.S. government security, the increase in U.S. bank reserves is due to fiscal policy and is not part of the intervention per se. My approach leaves fiscal policy unchanged because the total stock of U.S. government debt is unchanged. Balbach (1978) follows an approach very similar to the one used here.

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